

LONG TERM STEWARDSHIP MONITORING AND SENSORS

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LTS S&T Roadmap Target Form

Program Activity: Framework for Monitoring

Technical Capability: Monitoring Multimedia

Goal: ☒ **M** Reduce Cost

☐ **H** Reduce Uncertainty

☐ **H** Reduce Risk

Short-term(2008) Target:

Target Description:

- 1 – Produce inventory of monitoring methods for all pathways to exposure.
- 2 – Initiate technology to fill 30% gaps.
- 3 – Gap analysis.

Target Status: ☐ Process/Method Exists ☒ Process/Method Being Pursued ☒ No Known Process/Method

Status Justification:

- 1 – Pieces of inventory available, but not integrated (e.g., EPA-pathway analysis, NDAA, NOAA, WES-sediment management system analysis). No gap analysis exists. **(YELLOW)**
- 2 – Awaiting gap analysis, will redirect research. Portion will require new technology; other portions will use technologies in pipeline **(YELLOW)**.
- 3 – No gap analysis exists for monitoring systems **(RED)**

Mid-term(2014) Target:

Target Description:

Target Status: ☐ Process/Method Exists ☐ Process/Method Being Pursued ☐ No Known Process/Method

Status Justification:

Long-term(2020) Target:

Target Description:

Target Status: ☐ Process/Method Exists ☐ Process/Method Being Pursued ☐ No Known Process/Method

Status Justification:

LTS S&T Roadmap Target Form

Program Activity: Optimize the Monitoring System

Technical Capability: Optimizing networks for spatial and temporal sampling.

Goal: ☒ Reduce Cost

☐ Reduce Uncertainty

☐ Reduce Risk

Short-term(2008) Target: (see below)

Target Description:

- 1 – 30% of LTS sites going to closure use optimization strategy to design and emplace monitoring system by 2008. Most current applications use judgment sampling constrained by costs. This is for multi-media monitoring.
- 2 – By 2005, review and compare optimization approaches, perform gap analysis. This will use both ongoing OTD projects and literature review of optimizing monitoring system.
- 3 – By 2005, optimization guidance developed and disseminated. A guidance document to identify optimization issues and approaches will be developed through available examples and literature reviews. This document will describe data needs for various media. It is recognized that there are some site-specific issues for application and the document will reflect this.
- 4 – Application of optimization strategy at Rocky Flats. This will address the multimedia needs of a site and design an optimal monitoring system. There will be interactions between site personnel, regulators, and other stakeholders to support design of this system.

Target Status: ☐ Process/Method Exists ☐ Process/Method Being Pursued ☒ No Known Process/Method

Status Justification:

- 1 – This target depends on the development of the guidance for optimization that will be developed. Most sites currently use a judgment approach with cost constraints to approach this problem.
- 2 – Fernald, Rocky Flats (ASTD), NTS (ASTD) have ongoing projects that can be used as a basis for current technologies and approaches. There will be a literature review necessary for this.
- 3 – This guidance does not exist and is currently not being developed. It will use the results of the inventory and gap analysis for a basis.
- 4 – Using the guidance document, a major site will be selected for applying an optimized site-wide monitoring system. There are some examples of local sites where this has been done, such as operation of pump and treat systems, but no approach where multimedia system have been done.

Mid-term(2014) Target:

Target Description:

Target Status: ☐ Process/Method Exists ☐ Process/Method Being Pursued ☐ No Known Process/Method

Status Justification:

Long-term(2020) Target:

Target Description:

Target Status: ☐ Process/Method Exists ☐ Process/Method Being Pursued ☐ No Known Process/Method

Status Justification:

SS&IC - LTS S&T Roadmap Target Form**Program Activity:** Sensors and Monitoring Technology**Technical Capability:** Hardware Development (New GHBC methods, Wireless, Minuturization, Non-invasive, Reliability, Calibrations, Remote interrogation)**Goal:** ☒ Reduce Cost☒ Reduce Uncertainty☐ Reduce Risk**Short-term(2008) Target:** (see below)**Target Description:**

- 1 – In-situ analysis can be done in subsurface for five high-risk analytes or surrogates, by 2008.
- 2 – 10% of sensor arrays in field can deliver data wirelessly from subsurface, by 2008.
- 3 – Assurance by 2008 that 30 years hence, 50% of sensors still meet original goals.
- 4 – By 2008, 10% of LTS sites will use non-invasive methods for monitoring soil moisture or leak detection.

Target Status: ☐ Process/Method Exists ☐ Process/Method Being Pursued ☒ No Known Process/Method**Status Justification:**

- 1 – Nothing beyond theoretical work. Water content as a surrogate can and has been utilized. High-risk contaminants do not exist.
- 2 – Savannah River installed modem-based sensors. Goal is to develop strategies to incorporate and develop sensor arrays that deliver data wirelessly. Wireless sensing technologies exist in other fields, such as earthquake and mechanical engineering. These wireless sensors do not currently exist. An increase of 10% for the use of wireless sensors will reduce the costs on the monitoring network by improving data transfer capabilities.
- 3 – Duplicate installation with same XXXX and different XXXX monitoring same parameter but has not been compiled and evaluated. Monitoring program have not been conducted over a 30 year period. Information on sensor failure has Not been completed. Impact of install procedures not evaluated.
- 4 – EM, seismic, (micro) gravity are available but have not been applied specifically to monitor soil water content. Ground truthing and calibrations have not been conducted. This technology will allow rapid monitoring over areas without impacting the integrity of the system. Provides a larger number of data points to be measured.

Mid-term(2014) Target:**Target Description:****Target Status:** ☐ Process/Method Exists ☐ Process/Method Being Pursued ☐ No Known Process/Method**Status Justification:****Long-term(2020) Target:****Target Description:****Target Status:** ☐ Process/Method Exists ☐ Process/Method Being Pursued ☐ No Known Process/Method**Status Justification:**

SS&IC - LTS S&T Roadmap Target Form**Program Activity:** Design and Emplace Monitoring Systems**Technical Capability:** Identify Surrogate/Indicator Parameters**Goal:** ☒ **H** Reduce Cost☐ **M** Reduce Uncertainty☒ **H** Reduce Risk**Short-term(2008) Target:** Surrogates for High-Risk Contaminants/Processes**Target Description:** Identify five surrogates that could be used to track high-risk contaminants or processes.**Target Status:** ☐ Process/Method Exists ☐ Process/Method Being Pursued ☒ **X** No Known Process/Method

Status Justification: Very little research has been done to identify or utilize surrogates, rather than analyzing for a full suite of parameters. Water balance measurements in the vadose zone begin a surrogate process and should be further expanded. SRS VZMS – The Savannah River Site Vadose Zone Monitoring System Project is an example of water balance information as a surrogate for radionuclide migration through the vadose zone. UMTRA sites may have utilized surrogate methods.

Mid-term(2014) Target: Surrogate Application at LTS Sites**Target Description:** Surrogates identified above will be applied in the field for closed EM sites (LTS. This includes regulatory approval.**Target Status:** ☐ Process/Method Exists ☐ Process/Method Being Pursued ☒ **X** No Known Process/Method**Status Justification:** See comments above; little work in this area other than water balance work.**Long-term(2020) Target:****Target Description:****Target Status:** ☐ Process/Method Exists ☐ Process/Method Being Pursued ☐ No Known Process/Method**Status Justification:**

SS&IC - LTS S&T Roadmap Target FormProgram Activity: OperationsTechnical Capability: Validate System PerformanceGoal: ☒ Reduce Cost☒ Reduce Uncertainty☒ Reduce Risk**Short-term(2008) Target:** (see below)**Target Description:**

- 1 – Begin validating system performance at Rocky Flats and/or Fernald by 2008. **(YELLOW)**
- 2 – Determine validation metrics for sites where operational strategy have been applied by 2006. **(RED)**
- 3 – Draft for review system validating guidance document by 2005. **(RED)**

Target Status: ☐ Process/Method Exists ☒ Process/Method Being Pursued ☒ No Known Process/Method
Status Justification:

(see Target Status in parenthesis above)

Mid-term(2014) Target:**Target Description:**
Target Status: ☐ Process/Method Exists ☐ Process/Method Being Pursued ☐ No Known Process/Method
Status Justification:**Long-term(2020) Target:****Target Description:**
Target Status: ☐ Process/Method Exists ☐ Process/Method Being Pursued ☐ No Known Process/Method
Status Justification:

Monitoring and Sensors Work Group

- ***Activity 1: Develop framework for multimedia (owner: Dave&Bridget)***

- **Definition of Need**

Monitoring must be tailored to the specific site. This specific tailoring must reflect multiple criteria and constraints such as (1) the set of concern for the site, (2) specific pathways to exposure (e.g., air, surface water, groundwater, the media in which the contaminants may be transported), (3) the regulatory/operator/stakeholder performance criteria for the specific site, (4) the conceptual models (e.g. fate and transport) on which the assessment and reassessment is based, and (5) the constraints (e.g., surface access limits) that the selected remediation will impose on the site. All of these form the **framework** for monitoring in multimedia.

- i) Background Information: (This write-up was developed through the LTS Roadmap Dallas Workshop, and previous reports develop outside the workshop such as) see attached references

(Note to Reader: The Monitoring and Sensors Work-Group chose to due full write-ups including technical targets and maturity analysis for capabilities for which the group forecast high impact for all three goals: cost, uncertainty and risk reduction. However, we include write-ups with impact analysis for all capabilities that have high impact in one of the three goals. Such capabilities should be included in further analysis since the one or more areas of high impact may of such magnitude that such capabilities may greatly influence the clean-up objectives)

Capability 1.1: Develop framework for multimedia

- **Monitoring for multimedia as appropriate**

- i) ***Define the capability—***

This capability comprises (1) the ability to identify the monitoring need for different sites and transport media, (2) the ability to match the specific needs with existing and developing monitoring technologies, (3) the ability to identify technology gaps for which new technology is needed, and (4) the ability to initiate and complete a technology R&D to fill the identified gaps.

- ii) ***Value Proposition—***

Monitoring systems need to be tailored to the specific site and transport media. Currently, monitoring systems are develop using a “cookie cutter” approach and as a add-on at the end of the remediation plan. This approach leads to LTS monitoring systems that will cost multiples of the closures costs (e.g., DOE \$300,000,000+/yr cost for site wide water analyses) and will not accelerate the reduction of risk. This approach has also led to the stagnation of the state-of-the-practice so that it is now 25 years behind the state-of-the-art. State-of-the-art systems will have inherent reductions in cost and uncertainty, increase in robustness and longevity, and decrease in risk by allowing implementation of contingency actions promptly while they are technically feasible. The development of the framework for the monitoring system permits such systems to be optimized to specific site in terms accelerate reduction of risk, while reducing cost and increasing efficiency of closure.

- iii) ***Define which goal(s) is/are most impacted by improvement in the capability (cost, technical uncertainty, and risk).***

- (1) Reduce Cost – **High** – The workgroup forecasted high impact on cost since the development of the framework for monitoring wold reduce the cost of performing the essential stewardship activity **monitoring**. This forecast was based on the observation that having the framework for monitoring allows systems to be tailored to site needs and, therefore, optimized and inherently more effective.
 - (2) Reduce technical uncertainty – **High** - The workgroup forecasted that this capability would have high impact since the framework would provide better estimation of source terms, release rates, barrier failure mechanisms, contaminant fate and transport.

- (3) Reduce risk to public and environment – **High** - - The workgroup forecasted that this capability would have high impact since the framework would provide improved barrier failure detection, preemption, and improved plume tracking

iv) Define the improvement targets (metrics) achievable by 2008

- (1) Produce inventory of methods/techniques for monitoring all exposure pathways by 2003
- (2) Complete gap analysis by 2004
- (3) Initiate technology development to fill 30% of identified gaps by 2008

- v) There are many diverse technology approaches to address this needed capability. The March workshop will start to elucidate some of these paths

- vi) *“What is the status of technical maturity?”*: Pieces of the framework for monitoring in multimedia exist but have not piece together. Nor has a technology gap analysis been made to fill needs for site closure by 2008

– **Capability 1.2: Conceptual models (geologic, hydrologic, chemical, biologic)**

i) Define the capability—

The understanding of the geologic, hydrologic, chemical and biologic processes that control both contaminant fate and transport and the selected remediation approach are unified into the conceptual model for the site and remediation plan. The conceptual model is an essential tool on which we based the risk assessment, the design of the remediation plan, and the design of the monitoring system. The conceptual model also defines which parameters and parameters need to be modeled.

ii) Value Proposition —.

The conceptual model is an essential tool on which we based the risk assessment, the design of the remediation plan, and the design of the monitoring system. The conceptual model also defines which parameters and parameters need to be modeled.

iii) Define which goal(s) is/are most impacted by improvement in the capability (cost, technical uncertainty, and risk).

- (1) Reduce Cost – **Low** - The workgroup forecasted that this capability would have high impact since the capability would be neutral in terms of cost. This judgement is based on the assumption that development and validation of conceptual models will be require in all cases
- (2) Reduce technical uncertainty – **High** - The workgroup forecasted that this capability would have high impact since The workgroup forecasted that this capability would have high impact since the framework would provide better estimation of source terms, release rates, barrier failure mechanisms, contaminant fate and transport.
- (3) Reduce risk to public and environment – **Low** - The workgroup forecasted that this capability would have high impact since the capability would be neutral in terms of cost. This judgement is based on the assumption that development and validation of conceptual models will be require in all cases

– **Capability 1.3: Modeling**

i) Define the capability—

Modeling comprises the numerical models and analytical techniques that derive from the conceptual models and are used to update site assessment based on input from the monitoring system. Modeling, therefore, is essential in defining the inputs from the monitoring system and how the monitoring system is used trigger contingency plans.

ii) Value Proposition —

Modeling, therefore, is essential in defining the inputs from the monitoring system and how the monitoring system is used trigger contingency plans.

iii) ***Define which goal(s) is/are most impacted by improvement in the capability (cost, technical uncertainty, and risk).***

- (1) Reduce Cost – would not have impact beyond 2008
- (2) Reduce technical uncertainty - would not have impact beyond 2008
- (3) Reduce risk to public and environment - would not have impact beyond 2008

– ***Capability 1.4: Identifying applicable regulatory requirements***

i) ***Define the capability—***

As a basic site, the design and operation of a LTS monitoring system must meet the regulatory requirements. These requirements may be site, contaminant and pathway dependent. These requirements will define (1) what is to be monitored, (2) Where monitoring occurs, (3) How monitoring is going to be done, (4) When monitoring is done, and (5) How monitoring is reported.

ii) ***Value Proposition —.***

Must meet regulatory requirement, must be able to adapt to changing regulatory requirements (e.g., change in Arsenic standard)

iii) ***Define which goal(s) is/are most impacted by improvement in the capability (cost, technical uncertainty, and risk).***

- (1) Reduce Cost – **High** - The workgroup forecasted that this capability would have high impact since tailoring the monitoring approaches to provide the site specific regulatory requirements and imbedding a capability to adapt to changing risk-based regulatory requirement would have significant impact on cost.
- (2) Reduce technical uncertainty – **Low** -
- (3) Reduce risk to public and environment – **Low**-

References:

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Scanlon, B. R., S. W. Tyler, and P. J. Wierenga, 1997, Hydrologic issues in arid, unsaturated systems and implications for contaminant transport, Reviews in Geophysics, 35, 461-490

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United States Environmental Protection Agency. 1997a. Proceedings of the symposium on natural attenuation of chlorinated organics in groundwater; Dallas, Texas, September 11-13, EPA/540/R-97/504, Office of Research and Development. Washington, D.C.

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Monitoring and Sensors Work Group

Activity 2: Design and Emplace Monitoring Systems

Definition of Need

Monitoring systems for long-term stewardship must be designed to cost-effectively collect data that ensure protection of human health and the environment at sites with residual contamination and operating engineered remediation systems. Current approaches to monitoring systems are often focused on short-term monitoring where data are collected from numerous locations aboveground and belowground at a multitude of depths. These data are also usually collected quarterly and analyzed for an exhaustive list of constituents. These robust monitoring systems have not been designed for the purpose of long-term monitoring, where the goal should be to assess changes in site conditions. With the end in mind, new monitoring systems and approaches must be designed to meet the specific needs of long-term stewardship at a specific site, reducing uncertainties and risks, while maintaining reasonable costs. The ability to cost-effectively emplace these systems in the fields needs to be further developed.

Definition of Capability

Capabilities include the ability to design systems that focus on detection of critical changes in site conditions, rather than the ability to continually collect quantitative data on numerous parameters.

- Surrogates that can identify system changes rather than a complete suite of analytes must be identified, proven, and accepted by the appropriate regulatory bodies and other stakeholders.
- Statistical approaches to spatial and temporal design must be further developed and demonstrated to the appropriate regulatory authorities and other stakeholders to obtain their acceptance.
- New approaches to emplacement of sensors and other monitoring equipment should be developed and proven.

Value Proposition

Re-design of monitoring systems to meet long-term monitoring needs can save significant amounts of money as the number of monitoring points, the frequency of sampling, and the number of analytes are all significantly reduced to focus on identification of changes in a system rather than a complete quantitative characterization of the system. New methods for sensor emplacement also have tremendous potential to save significant dollars.

Goals Impacted by Improvements in the Capability

- (1) Reduce Cost – High. The actual amount of monitoring data to be collected would be significantly reduced, while targeting the specific needs of long-term stewardship.
- (2) Reduce technical uncertainty – Low. Technical uncertainty can only be reduced by proving that more cost-effective systems targeting detection of changes will meet regulatory and stakeholder requirements. Demonstrated proof of performance of surrogates to represent high-risk contaminants will also reduce uncertainties.
- (3) Reduce risk to the public and environment – Low. Risk can only be reduced by proving the performance of the new cost-effective monitoring systems.

Metrics by 2008

- Review and compare design of current monitoring systems and emplacement strategies to identify gaps and areas for improvements in cost and performance.
- Identify and test five surrogates that could be used to track high-risk contaminants.
- Design state-of-the-art monitoring system that incorporates accessibility, repairability, and upgradeability for a facility/operable unit at Rocky Flats or an Ohio site.
- Develop guidance document on design and emplacement of monitoring systems for a broad spectrum of sites where waste is left in place.

Technical Approaches

A myriad of approaches are currently available to monitor multimedia at contaminated sites. Review of current approaches will prove useful in identification of gaps and areas for improvement.

Technical Maturity

Monitoring systems currently exist, but most focus on emplacement of monitoring wells, collection of groundwater or vadose zone samples and analysis in the laboratory. A few real-time sensors have been developed and some monitoring systems utilize field analytical techniques. However, there is room for significant improvement in this area. More sensors and field analytical techniques should be developed and those that exist need to be further proven so they can gain regulatory and stakeholder acceptance for long-term stewardship applications.

Activity 3 – Optimizing monitoring systems – Everett Springer

Definition of need: Site closure with residual contamination and engineered remediation systems will require monitoring of relevant pathways to protect human health and the environment and to insure that remediation systems are operating properly. Monitoring is required by regulations, and the administrative authority determines the time frame or length of monitoring period. The optimizing monitoring systems activity will seek to develop tools to optimize the design of monitoring systems for long-term stewardship (LTS) sites considering costs, regulatory, and site factors. The goal is to monitor in space and time to meet regulatory requirements and/or assess residual risks using a minimum number monitoring stations located where the contaminant or surrogate variable is most likely to be and to sample at a frequency that will capture contaminant movement to confirm that all processes are operating effectively or trigger any necessary contingency action.

Definition of the capability: Optimizing monitoring systems is a set of tools, at this time conceived to be computer programs, that will tell a LTS manager where and how often measurements or samples will need to be taken to determine if risks have increased, or the remedial system is operating properly. For LTS, monitoring systems will take physical, chemical, and biological measurements or samples in the subsurface, on the surface, and in the atmosphere. Uncertainties in conceptual models, key parameters controlling important fluxes, and forcing functions will require a statistically based monitoring network. The monitoring network will be characterized by: 1) the zone of influence (support) of the sensors/sampling device, 2) the spacing between sensors, and 3) the extent of the domain/site that needs to be monitored. Initial applications will see tools for each pathway, air, surface and subsurface, because models and approaches that consider coupled systems are currently limited, but as research proceeds a coordinated monitoring approach can be built.

Value proposition: Tools that optimize monitoring systems will lead to a 50 percent cost reduction and decrease uncertainty by a factor of 5 over systems based on judgement or regular grid systems. An optimized monitoring system will allow risks and uncertainty associated with risks to be assessed more accurately at all LTS sites.

Over the life of a LTS project, monitoring costs can be substantial even exceeding the costs of the remediation system. The capability to reduce monitoring while retaining the critical information for either the site or the engineered barrier will lead to enhanced efficiency of the LTS project.

Goals: Costs are greatly impacted by developing tools for monitoring system optimization. The potential to reduce the number of monitoring locations and the frequency of sampling while maintaining the confidence that risks are being assessed can lead to significant costs savings.

Technical uncertainty will be impacted by reducing the error bands at all LTS site by a factor of 2 to 5. This will be achieved through monitoring site processes consistent with the site conceptual model and operation of the remediation system. This tool will provide a basis for leaving contaminants in place by providing regulators and stakeholders the understanding that monitoring is able to detect changes given current understanding of site processes.

Risk will be assessed using data from the monitoring system. All LTS sites will benefit from this technology, and the goal of reducing or ending LTS activities will depend on results from a monitoring system.

Metrics for 2008:

1. By 2005 a review and comparison of optimization approaches for air, surface and subsurface pathways will be completed. This review will use both ongoing OTD projects and literature review.
2. By 2005 an initial guidance document for optimizing subsurface monitoring systems will be developed and disseminated. The document will describe data needs and address site-specific issues.

3. Application of optimization strategy to Rocky Flats. The multimedia needs of this site will be considered and an optimal monitoring system will be designed. Interactions between site personnel, regulators, and stakeholders will support design of this system.
4. By 2008, thirty (30) percent of the sites going to closure use an optimization approach to design and emplace monitoring systems.

There are multiple technical approaches to this technology. There are standard statistical methods and as an alternative there are Bayesian approaches.

The status of technical maturity is varied. For saturated groundwater cases, much work has been done on optimal operation of pump and treat systems, locating capture wells, and monitoring system design. For the vadose zone less effort has been made. For surface water systems, there has been considerable work in perennial streams, but much less on ephemeral streams characteristic of arid and semiarid locations.

Activity 4: Information Visualization & Dissemination

Target – Establish by 2008 Information Visualization & Dissemination Systems at all sites and a means of communicating this information to: 1) Concerned or involved workers at the sites; 2) regulatory agencies; and 3) interested parties at other DOE sites and/or Headquarters.

Definition of Need: All sites across the DOE complex have an existing need to collect, analyze, and provide site specific information regarding site environmental conditions, remedial actions, contaminant plumes, and monitoring programs to a variety of concerned or involved parties, including site workers and program managers, regulators, and interested personnel at other DOE sites and/or Headquarters. The development of a complex-wide, integrated, Information Visualization & Dissemination (IV&D) System, fully capable of storing and displaying environmental data and interpretations (raw field data, calculations, maps, conclusions, and projections) should be initiated to facilitate effective management of contaminant releases and/or residual contamination at all sites under the Long-Term Stewardship (LTS) Program.

Definition of Capability: DOE sites are currently required to collect, evaluate, and communicate environmental data and interpretations to both DOE management and regulatory agencies on a periodic and/or as-needed basis. Accordingly, a means of presenting and disseminating this information to involved parties already exists, but exists at different levels of development, complexity, and sophistication, exists in a wide variety of presentation formats, and most commonly represents dated information (available weeks, months, or more after the original data was gathered). Further, this information may not be readily available to interested parties at other sites across the complex with similar interests or contaminant concerns. The development of an integrated, complex-wide, web-based, upgradeable, IV&D System, fully capable of presenting information ranging from raw data to graphic displays of data, on as near real-time basis as state-of-the-art technology allows, would promote enhanced management coordination, efficiency, decision making, and benefit the LTS Program as a whole.

Develop Value Proposition: The development of a complex-wide, web-based, IV&D System would benefit site workers, program managers, and others responsible for managing environmental releases or monitoring contaminant plumes, and would facilitate decision making in the field. In addition, the ability to present real-time data would enhance understanding, communication, and negotiation with regulatory agencies, as well as promote reliability and efficiency in the management of the LTS Program.

Definition of Impacts: Development and implementation of an upgradeable IV&D System and corresponding protocols for access, data entry, and usage will increase costs. However, these costs should be offset by reductions in technical uncertainty and a corresponding reduction in perceived risks.

Definition of Improvement Targets:

- By 2004, complete a requirements analysis to guide the design of the IV&D System.
- By 2005, develop an idealized, generic IV&D System to be utilized at all sites.
- By 2006, tailor the generic IV&D System to accommodate site-specific needs.
- By 2007, establish protocols regarding data entry, usage, and user access.
- By 2008, implement IV&D Systems at all sites across the DOE Complex.

Outreach and Training

Target – Establish by 2008 Public Outreach and Training Programs for the purpose of both informing and educating the public with respect to site conditions, associated hazards and risks, and the relative merits and benefits of implementing new and innovative approaches to monitoring and the Long-Term Stewardship Program.

Definition of Need: All DOE sites have an existing need and facilities to provide information to the public regarding site activities, environmental contaminants, associated hazards and risks, and the status of remedial actions taken to mitigate and/or monitor those risks. In addition to the local residents and community leaders that obviously have a stake in these site activities, other concerned parties that may make use of the site resource centers may include members of Congress, other agencies, regulators, researchers, and members of industry. The development of a complex-wide, integrated Public Outreach and Training Program (POTP) should be initiated at all DOE sites for the purpose of expanding existing capabilities and actively informing, training, and educating the public with respect to remediation, hazards and associated risks, monitoring, technology advancements, and the Long-Term Stewardship (LTS) Program.

Definition of Capability: All sites across the DOE complex currently provide public reading rooms and/or resource centers as a means of providing regulatory documents, publications, and newsletters to concerned stakeholders. Expanding the existing capabilities to actively promote POTP provides not only a means of informing the public, but also provides a forum to present and define options and gain feedback, promote public involvement, generate interest, and gain the support of stakeholders. The development of a complex-wide, integrated POTP should include a web-based, interactive, updateable system, accessible to both onsite and remote users, consistent across all sites with respect to quality, capability, layout and software. In addition to the web-based POTP, the system should include telephones, staffed help centers to assist the public, and informed personnel capable of communicating the technical aspects of site activities and the LTS Program to stakeholders.

Develop Value Proposition: The development of an integrated POTP would benefit DOE's interaction with the public by actively providing information and feedback. Educating the public with respect ongoing remedial activities, proposed monitoring techniques, and technological advances would help to gain the public's confidence and foster support for the LTS Program. In addition, training the public with respect to known or potential hazards and corresponding risks will help mitigate the public's fear of those risks and facilitate acceptance of the LTS Program.

Definition of Impacts: Implementation of the POTP will incur additional costs associated with the development of the system. Although little to no reduction in technical uncertainty is anticipated, substantial reductions in perceived risk should be expected in that educating, training, and communicating with the public with respect to monitoring and the LTS Program should help to allay the public's fear, doubt, and mistrust regarding the management of site contaminants and perceived risks.

Definition of Improvement Targets:

- By 2005, complete a requirements analysis to guide the design of the POTP.
- By 2008, implement a consistent, integrated POTP at all sites across the DOE complex.

Information Visualization & Dissemination

Target – Establish by 2008 Information Visualization & Dissemination Systems at all sites and a means of communicating this information to: 1) Concerned or involved workers at the sites; 2) regulatory agencies; and 3) interested parties at other DOE sites and/or Headquarters.

Definition of Need: All sites across the DOE complex have an existing need to collect, analyze, and provide site specific information regarding site environmental conditions, remedial actions, contaminant plumes, and monitoring programs to a variety of concerned or involved parties, including site workers and program managers, regulators, and interested personnel at other DOE sites and/or Headquarters. The

development of a complex-wide, integrated, Information Visualization & Dissemination (IV&D) System, fully capable of storing and displaying environmental data and interpretations (raw field data, calculations, maps, conclusions, and projections) should be initiated to facilitate effective management of contaminant releases and/or residual contamination at all sites under the Long-Term Stewardship (LTS) Program.

Definition of Capability: DOE sites are currently required to collect, evaluate, and communicate environmental data and interpretations to both DOE management and regulatory agencies on a periodic and/or as-needed basis. Accordingly, a means of presenting and disseminating this information to involved parties already exists, but exists at different levels of development, complexity, and sophistication, exists in a wide variety of presentation formats, and most commonly represents dated information (available weeks, months, or more after the original data was gathered). Further, this information may not be readily available to interested parties at other sites across the complex with similar interests or contaminant concerns. The development of an integrated, complex-wide, web-based, upgradeable, IV&D System, fully capable of presenting information ranging from raw data to graphic displays of data, on as near real-time basis as state-of-the-art technology allows, would promote enhanced management coordination, efficiency, decision making, and benefit the LTS Program as a whole.

Develop Value Proposition: The development of a complex-wide, web-based, IV&D System would benefit site workers, program managers, and others responsible for managing environmental releases or monitoring contaminant plumes, and would facilitate decision making in the field. In addition, the ability to present real-time data would enhance understanding, communication, and negotiation with regulatory agencies, as well as promote reliability and efficiency in the management of the LTS Program.

Definition of Impacts: Development and implementation of an upgradeable IV&D System and corresponding protocols for access, data entry, and usage will increase costs. However, these costs should be offset by reductions in technical uncertainty and a corresponding reduction in perceived risks.

Definition of Improvement Targets:

- By 2004, complete a requirements analysis to guide the design of the IV&D System.
- By 2005, develop an idealized, generic IV&D System to be utilized at all sites.
- By 2006, tailor the generic IV&D System to accommodate site-specific needs.
- By 2007, establish protocols regarding data entry, usage, and user access.
- By 2008, implement IV&D Systems at all sites across the DOE Complex.

Outreach and Training

Target – Establish by 2008 Public Outreach and Training Programs for the purpose of both informing and educating the public with respect to site conditions, associated hazards and risks, and the relative merits and benefits of implementing new and innovative approaches to monitoring and the Long-Term Stewardship Program.

Definition of Need: All DOE sites have an existing need and facilities to provide information to the public regarding site activities, environmental contaminants, associated hazards and risks, and the status of remedial actions taken to mitigate and/or monitor those risks. In addition to the local residents and community leaders that obviously have a stake in these site activities, other concerned parties that may make use of the site resource centers may include members of Congress, other agencies, regulators, researchers, and members of industry. The development of a complex-wide, integrated Public Outreach and Training Program (POTP) should be initiated at all DOE sites for the purpose of expanding existing capabilities and actively informing, training, and educating the public with respect to remediation, hazards and associated risks, monitoring, technology advancements, and the Long-Term Stewardship (LTS) Program.

Definition of Capability: All sites across the DOE complex currently provide public reading rooms and/or resource centers as a means of providing regulatory documents, publications, and newsletters to concerned stakeholders. Expanding the existing capabilities to actively promote POTP provides not only a means of informing the public, but also provides a forum to present and define options and gain feedback, promote public involvement, generate interest, and gain the support of stakeholders. The development of a complex-wide, integrated POTP should include a web-based, interactive, updateable system, accessible to both onsite and remote users, consistent across all sites with respect to quality, capability, layout and software. In addition to the web-based POTP, the system should include telephones, staffed help centers to assist the public, and informed personnel capable of communicating the technical aspects of site activities and the LTS Program to stakeholders.

Develop Value Proposition: The development of an integrated POTP would benefit DOE's interaction with the public by actively providing information and feedback. Educating the public with respect ongoing remedial activities, proposed monitoring techniques, and technological advances would help to gain the public's confidence and foster support for the LTS Program. In addition, training the public with respect to known or potential hazards and corresponding risks will help mitigate the public's fear of those risks and facilitate acceptance of the LTS Program.

Definition of Impacts: Implementation of the POTP will incur additional costs associated with the development of the system. Although little to no reduction in technical uncertainty is anticipated, substantial reductions in perceived risk should be expected in that educating, training, and communicating with the public with respect to monitoring and the LTS Program should help to allay the public's fear, doubt, and mistrust regarding the management of site contaminants and perceived risks.

Definition of Improvement Targets:

- By 2005, complete a requirements analysis to guide the design of the POTP.
- By 2008, implement a consistent, integrated POTP at all sites across the DOE complex.

Monitoring and Sensors Activity 6

Need: Many federal and state programs including those regulated under RCRA, CERCLA and the Clean Air Act requires characterization and monitoring to detect contamination in the environment and to provide data to develop plans for prevention of new contamination. The primary objective of monitoring programs is to ensure the protection of human health and the environment and to reduce the risk associated with exposure by monitoring for the contaminant of concern. Hundreds of specific methods and techniques exist for characterization, sampling and monitoring the air, soil water environment. Existing methods are often refined and new methods are continually being developed. This is particularly true for media that

have not received regulatory attention in the past. To assure the protection of human health and the environment, LTS will need the development of new sensors, applications and software to provide real-time monitoring for the related but differing regulatory endpoints. Multimedia environmental monitoring networks need to be developed to take advantage of new technologies currently available including nanotechnology, genomic sequencing, and miniturization. Sensor technologies for multimedia environmental monitoring will incorporate new and innovative approaches to hardware, application, and software development. Hardware development may include new GHBC methods, wireless miniturization, remote interrogation and non-invasive techniques. In addition, applications and software will be developed to integrate point-volume sensing and to increase the reliability and calibration.

Definitions of Capabilities

LTS will require the development of multimedia sensor technologies or techniques which either improve the capacity to monitor the presence and concentration of contaminants or significantly decrease the cost of existing techniques for monitoring contaminants. New sensors are needed to measure GHBC analytes and surrogates, monitor remotely and wirelessly, miniaturize existing sensors, and increase reliability and calibration. Techniques that allow for remote operations through telemetry or wireless are of interest, as are techniques, which in conjunction with modeling processes, allow for optimization of monitoring and/or operating treatment systems. In addition, new sensors will need to be developed to measure GHBC properties and improve characterization. In-situ techniques for developing GHBC surrogate and analytes are needed which provide reliable data to the LTS site manager. Improving the reliability of the system will decrease the need for replacement and maintenance. These new technologies must also improve or decrease the cost of maintenance or replacement to be effective. In addition, self calibration of the systems will provide the reliability of the sensor. Software development will provide the LTS site manager with a user friendly interface to data integration into reports.

Value Proposition

Protection of human health and the environment requires rapid, precise sensors capable of detecting pollutants at both the macro-scale and molecular level. Major improvement in process control, compliance monitoring, and environmental decision making could be achieved if more accurate, less costly, more sensitive techniques were available. In addition, linking these monitoring devices to data collection and storage systems would improve the user friendliness and enhance the ability to detect problems. New sensors will lead to a 25 percent cost reduction by reducing the need for invasive techniques and increase the accuracy and reliability of the sensors by a factor of 2. LTS is particularly interested in remote, in situ, and continuous monitoring devices that yield real-time information, or that can detect pollutants at very low concentrations.

Goal

The goals for LTS with regards to sensors include:

1. The ability to characterize any non-negligible contamination efficiently, exploiting wherever possible in-situ, real-time measurement technology,
2. Understand subsurface contaminant fate and transport in nearly all media, enabling credible and reliable planning for site remediation, closure, and LTS,
3. Have developed waste stream characterization to a routine operation,
4. Be able to monitor waste and nuclear materials in the environment using real time sensors and monitors,
5. Monitor long-term remediation processes efficiently with stakeholder approval,
6. Minimizing or eliminating any risk or perceived risk to human health and the environment,
7. Developed a new generation of sensors and monitors capable of unattended operations, self-validating, and automated reporting with minimal maintenance,
8. Acquire an understanding of contaminant fate and transport which support the judicious selection of monitors, monitoring parameter, and decision strategies,
9. Nurtured the acceptance of regulatory paradigm geared to these systems and understanding.
10. Make full use of next-generation sensors having significantly toward their development.

11. Enhance and improve the monitoring of difficult media such as the unsaturated zone.

Examples of research interests include the development of new sensors for efficient and rapid in situ biochemical detection of pollutants and specific pathogens in the environment; sensors capable of continuous measurement over large areas or at greater depth in the unsaturated zone, including those connected to nanochips for real-time continuous monitoring; and sensors that utilize lab-on-a-chip technology. Research in this topic area may also involve sensors that can be used in monitoring or process control to detect or minimize pollutants or their impact on the environment.

Metrics

1. 10% of sensor arrays in field can deliver data wirelessly from subsurface, by 2008;
2. Insitu-analysis can be done in subsurface for 5 high-risk analytes or surrogates, by 2008;
3. Assurance by 2008 that 30 years out, 50% of sensors still meet their original
4. By 2008 the application of volume integrating methods reduces the use of point sensors at 10% of closed sites.

Question: “Are there multiple technical approaches?”

Yes, for many of the parameters there are different technical approaches. For example, tensiometers measure soil moisture potential with pressure gauges, pressure transducers, and then to determine water flux, direction and soil-water content.

Question: “What is the status of technical maturity?”

Generally, many of the sensors and monitoring devices are in the early to mid stages of development for most media. Field application is at the laboratory research level or field demonstrations. State and Federal regulators either do not require or are not aware of these techniques. Also, performance data is not available for the different types of media or contaminants and wide natural conditions.

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14. Have developed waste stream characterization to a routine operation,

15. Be able to monitor waste and nuclear materials in the environment using real time sensors and monitors,
16. Monitor long-term remediation processes efficiently with stakeholder approval,
17. Minimizing or eliminating any risk or perceived risk to human health and the environment,
18. Developed a new generation of sensors and monitors capable of unattended operations, self-validating, and automated reporting with minimal maintenance,
19. Acquire an understanding of contaminant fate and transport which support the judicious selection of monitors, monitoring parameter, and decision strategies,
20. Nurtured the acceptance of regulatory paradigm geared to these systems and understanding.
21. Make full use of next-generation sensors having significantly toward their development.
22. Enhance and improve the monitoring of difficult media such as the unsaturated zone.

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Metrics

5. 10% of sensor arrays in field can deliver data wirelessly from subsurface, by 2008;
6. Insitu-analysis can be done in subsurface for 5 high-risk analytes or surrogates, by 2008;
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Generally, many of the sensors and monitoring devices are in the early to mid stages of development for most media. Field application is at the laboratory research level or field demonstrations. State and Federal regulators either do not require or are not aware of these techniques. Also, performance data is not available for the different types of media or contaminants and wide natural conditions.

Activities / Capabilities			Impact by 2008	Impact beyond 2008	Targets			Resp. WG Member
					Short-term (2008)	Mid-term (2014)	Long-term (2020)	
1. Develop framework for multimedia								
1.1 Monitoring for multimedia as appropriate								Dave/Bridge
G1: reduce cost			M	M	Produce inventory of methods/techniques for monitoring all exposure pathways by 2004; Complete gap analysis by 2004; Initiate technology development to fill 30% of identified gaps by 2008			
G2: reduce technical uncertainty			H	H				
G3: reduce risk to public and environment			H	H				
1.2 Conceptual models (geologic, hydrologic, chemical, biologic)								
G1: reduce cost			L	L				
G2: reduce technical uncertainty			H	H				
G3: reduce risk to public and environment			L	L				
1.3 Modeling								
G1: reduce cost				L				
G2: reduce technical uncertainty				M				
G3: reduce risk to public and environment				M				
1.4 Identifying applicable regulatory requirements								
G1: reduce cost			H	H				
G2: reduce technical uncertainty			L	L				
G3: reduce risk to public and environment			L	L				
2. Design and Emplace monitoring system								
2.1 Inventorying available technologies and gaps								Dawn
G1: reduce cost								
G2: reduce technical uncertainty								
G3: reduce risk to public and environment								
2.2 Incorporating accessibility, reparability, upgradeability								
G1: reduce cost			H	H				
G2: reduce technical uncertainty			M	M				
G3: reduce risk to public and environment			M	M				
2.3 Identifying surrogates/indicator parameters					Identify 5 surrogates for high-risk contaminants pr processes, by 2008; Application of all surrogates applied at sites by 2014.			
G1: reduce cost								
G2: reduce technical uncertainty			H	H				
G3: reduce risk to public and environment			M	M				
2.4 Identification of constraints (hydrogeologic, facilities)								
G1: reduce cost			M	M				
G2: reduce technical uncertainty			H	H				
G3: reduce risk to public and environment			M	M				
2.5 Evaluate emplacement strategies								
G1: reduce cost			H	H				
G2: reduce technical uncertainty			M	M				
G3: reduce risk to public and environment			M	M				

Long-Term Stewardship

Science and Technology
Roadmap

Monitoring and Sensors



Long-Term Stewardship

Science and Technology
Roadmap

Work Group Members

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Everett Springer	Los Alamos National Laboratory
Ron Wilhelm	Environmental Protection Agency

Vision Statement

By the year 2008 ... We will have created the ability to design, optimize, emplace and validate robust, repairable and upgradeable monitoring systems and approaches that can perform trend analyses, identify triggers for contingency actions and meet health, safety, regulatory requirements and risk management considerations.

Activities

- **Develop framework for multimedia**
- **Design and emplace monitoring systems**
- **Optimize monitoring systems**
- **Operations**
- **Communication**
- **Sensor Technologies**

M&S - Activity 1

Activities / Capabilities	Impact by 2008	Impact beyond 2008	Targets		
			Short-term (2008)	Mid-term (2014)	Long-term (2020)
1. Develop framework for multimedia					
1.1 Monitoring for multimedia as appropriate			Produce inventory of methods/techniques for monitoring all exposure pathways by 2004; Complete gap analysis by 2004; Initiate technology development to fill 30% of identified gaps by 2008		
G1: reduce cost	M	M			
G2: reduce technical uncertainty	H	H			
G3: reduce risk to public and environment	H	H			
1.2 Conceptual models (geologic, hydrologic, chemical, biologic)					
G1: reduce cost	L	L			
G2: reduce technical uncertainty	H	H			
G3: reduce risk to public and environment	L	L			
1.3 Modeling					
G1: reduce cost		L			
G2: reduce technical uncertainty		M			
G3: reduce risk to public and environment		M			
1.4 Identifying applicable regulatory requirements					
G1: reduce cost	H	H			
G2: reduce technical uncertainty	L	L			
G3: reduce risk to public and environment	L	L			

M&S - Activity 2

Activities / Capabilities	Impact by 2008	Impact beyond 2008	Targets		
			Short-term (2008)	Mid-term (2014)	Long-term (2020)
2. Design and Emplace monitoring system					
2.1 Inventorying available technologies and gaps					
G1: reduce cost					
G2: reduce technical uncertainty					
G3: reduce risk to public and environment					
2.2 Incorporating accessibility, repairability, upgradeability					
G1: reduce cost	H	H			
G2: reduce technical uncertainty	M	M			
G3: reduce risk to public and environment	M	M			
2.3 Identifying surrogates/indicator parameters			Identify 5 surrogates for high-risk contaminants pr processes, by 2008; Application of all surrogates applied at sites by 2014.		
G1: reduce cost	H	H			
G2: reduce technical uncertainty	M	M			
G3: reduce risk to public and environment	H	H			
2.4 Identification of constraints (hydrogeologic, facilities)					
G1: reduce cost	M	M			
G2: reduce technical uncertainty	H	H			
G3: reduce risk to public and environment	M	M			
2.5 Evaluate emplacement strategies					
G1: reduce cost	H	H			
G2: reduce technical uncertainty	M	M			
G3: reduce risk to public and environment	M	M			
2.6 Scaling					
G1: reduce cost	M	M			
G2: reduce technical uncertainty	H	H			
G3: reduce risk to public and environment	M	M			

M&S - Activity 3

Activities / Capabilities	Impact by 2008	Impact beyond 2008	Targets		
			Short-term (2008)	Mid-term (2014)	Long-term (2020)
3. Optimize monitoring system					
3.1 Optimizing networks (spatial and temporal)			30% of LTS sites (going to closure) use optimization strategy to design and emplace monitoring system, by 2008; Review inventory and gap analysis of optimized strategies for multimedia, by 2005; Develop and disseminate optimization guidance, by 2005;		
G1: reduce cost	H	H			
G2: reduce technical uncertainty	H	H			
G3: reduce risk to public and environment	H	H			
3.2 Adaptive Sampling					
G1: reduce cost					
G2: reduce technical uncertainty					
G3: reduce risk to public and environment					

M&S - Activity 4

Activities / Capabilities	Impact by 2008	Impact beyond 2008	Targets		
			Short-term (2008)	Mid-term (2014)	Long-term (2020)
4. Operations					
4.1 Data management					
G1: reduce cost	H	H			
G2: reduce technical uncertainty	M	M			
G3: reduce risk to public and environment	L	L			
4.2 Maintenance					
G1: reduce cost		L			
G2: reduce technical uncertainty		M			
G3: reduce risk to public and environment		M			
4.3 Validate system performance					
			Begin validating system performance at Rocky Flats and Fernald, by 2008; Review inventory and gap analysis of optimized strategies for multimedia, by 2005; Determine validation metrics for applicable sites, by 2008; Issue first draft of guidance for Sys		
G1: reduce cost	H	H			
G2: reduce technical uncertainty	H	H			
G3: reduce risk to public and environment	H	H			
4.4 Reliability & Calibrations					
G1: reduce cost	L	L			
G2: reduce technical uncertainty	M	M			
G3: reduce risk to public and environment	H	H			

M&S - Activity 5

Activities / Capabilities	Impact by 2008	Impact beyond 2008	Targets		
			Short-term (2008)	Mid-term (2014)	Long-term (2020)
5. Communication *					
5.1 Information visualization and dissemination				Real-time	
G1: reduce cost	L	L			
G2: reduce technical uncertainty	M	M			
G3: reduce risk to public and environment	H	H			
5.2 Outreach and Training					
G1: reduce cost	L	L			
G2: reduce technical uncertainty	L	L			
G3: reduce risk to public and environment	H	H			
5.3 Technical Transfer					
G1: reduce cost		L			
G2: reduce technical uncertainty		M			
G3: reduce risk to public and environment		L			
* crosscuts all groups					

M&S - Activity 6

Activities / Capabilities	Impact by 2008	Impact beyond 2008	Targets		
			Short-term (2008)	Mid-term (2014)	Long-term (2020)
6. Sensor Technologies					
6.1 Hardware Development (New GHBC methods, Wireless, Minutization, Non-invasive, Reliability, Calibrations, Remote interrogation)			10% of sensor arrays in field can deliver data wirelessly from subsurface, by 2008; Insitu analysis can be done in in subsurface for 5 high-risk analytes or surrogates, by 2008; Assurance by 2008 that 30 years out, 50% of sensors still meet their original		
G1: reduce cost	H	H			
G2: reduce technical uncertainty	H	H			
G3: reduce risk to public and environment	M	M			
6.2 Applications and Software (Point and volume sensing, reliability, calibrations)			By 2008 the application of volume integrating methods reduces the use of point sensors at 10% of closed sites.		
G1: reduce cost	H	H			
G2: reduce technical uncertainty	H	H			
G3: reduce risk to public and environment	H	H			